

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554**

In the Matter of

WorldVu Satellites Limited

Petition for a Declaratory Ruling
Granting Access to
the U.S. Market for the
OneWeb System

IBFS File No.
SAT-LOI-20160428-00041

REPLY COMMENTS OF TERRA BELLA TECHNOLOGIES INC.

Opponents and commenters on OneWeb's petition rightly emphasize that the petition cannot be considered in isolation. Rather, as the Commission recognized in its *Public Notice*, OneWeb's application to provide service in the United States using its proposed non-geostationary-satellite orbit (NGSO) constellation must be viewed in the overall context of other "NGSO-like satellite operation[s]" that may use, or seek to use, Ka-band frequencies.¹

Use of the Ka-band for NGSO Earth Exploration Satellite Service (EESS) systems is an important part of that overall context. Supporting the development of satellite imaging and other services that can boost economic growth, increase agricultural productivity, speed disaster response, and further other critical missions, should be part of the Commission's policy for utilization of the Ka-band. In particular, the Commission should identify the frequencies between 25.5 and 27.0 GHz as well-suited to EESS space-to-Earth

¹ Public Notice, *Satellite Policy Branch Information: OneWeb Petition Accepted for Filing (IBFS File No. SAT-LOI-20160428-00041) and Cut-Off Established for Additional NGSO-Like Satellite Applications or Petitions for Operations in the 10.7-12.7 GHz, 14.0-14.5 GHz, 17.8-18.6 GHz, 18.8-19.3 GHz, 27.5-28.35 GHz, 28.35-29.1 GHz, and 29.5-30.0 GHz Bands*, DA 16-804, at 2 (rel. July 15, 2016) (*Public Notice*); see, e.g., Comments of ViaSat, Inc., IBFS File No. SAT-LOI-20160428-00041, at 1-2 (filed Aug. 15, 2016) (noting that "consideration of [OneWeb's] waiver requests is based in part on public interest considerations related to the other NGSO applications expected to be filed in this processing round. Thus, OneWeb's waiver requests cannot be considered in isolation").

communications, and between 29.3 and 29.5 GHz as well-suited to EESS Earth-to-space communications, and incorporate those identifications into its management of the band.

Although Terra Bella Technologies Inc. (Terra Bella)² is not yet at the stage of applying for a spectrum authorization within the scope of the *Public Notice*, Terra Bella has developed plans to utilize Ka-band frequencies for space-to-Earth satellite payload data downlinks and Earth-to-space satellite control uplinks to support its non-Federal NGSO EESS system. Terra Bella specifically anticipates seeking authorization for satellite payload data downlinks between 25.5 and 27.0 GHz, and for satellite command and control uplinks between 29.3 and 29.5 GHz. Terra Bella's interest illustrates the growing demand for these frequencies in the United States and internationally, which should inform the Commission's evaluation of currently pending applications.

DISCUSSION

I. Terra Bella's EESS Service

Terra Bella currently operates three commercial remote sensing satellites, SkySat-1 through SkySat-3, as part of a NGSO EESS high-resolution imagery satellite system under FCC Call Sign S2862.³ The Commission has authorized 12 additional satellites, SkySat-4 through SkySat-15.⁴ The satellites in the system are authorized to use 8075, 8200, and 8325 MHz for imagery data downlinks and 8375 MHz for telemetry downlinks. These frequencies are within the 8025-8400 MHz (X-band) range where EESS has a primary spectrum allocation.

There is, however, a growing community of users—Federal, non-Federal, and international—in the X-band, leading to a high density of data downlink transmission

² Terra Bella is wholly owned by Google Inc., which offers online users access to satellite imagery and other online mapping resources.

³ See IBFS File No. SAT-LOA-20120322-00058 (grant issued Sept. 20, 2012) (SkySat-1 and SkySat-2); IBFS File No. SAT-MOD-20150408-00019 (grant in part issued June. 6, 2016).

⁴ See IBFS File No. SAT-MOD-20150408-00019 (grant issued Aug. 31, 2016).

operations. This is particularly true for Earth stations in the preferred polar regions.⁵ As a result, coordination between missions and interference mitigation are becoming increasingly challenging. In recognition of this growing congestion, the International Telecommunications Union (ITU) provided guidance in ITU-R SA.1810, suggesting consideration of the Ka-band for future EESS missions.⁶ As the ITU explains, “the use of the 25.5-27 GHz band by Earth exploration-satellites should be considered in particular if [other techniques recommended in SA. 1810] cannot adequately resolve potential spectrum-sharing and/or unwanted emission issues, once suitable ground infrastructures are available.”⁷

In addition to the X-band, NGSO EESS missions commonly use the S-band (2025-2110 MHz) for satellite command and control uplinks (Earth-to-space). But use of the S-band faces substantial constraints as well. S-band EESS uplinks have a primary allocation in the International Table of Frequency Allocations (*International Table*), but only a secondary allocation in the Commission’s U.S. Table for non-Federal users, pursuant to footnote US347.⁸ In the United States, primary status is given to Television Broadcast Auxiliary Services. Thus it is generally difficult to share the S-band near significant television markets, while areas distant from major markets often have insufficient Internet connectivity to support command uplink Earth stations also used for satellite payload data downlinks.

II. Suitability of Ka-Band Frequencies for EESS Links

In light of these challenges, Terra Bella has developed plans to use Ka-band spectrum for both space-to-Earth data downlinks and Earth-to-space satellite control uplinks on some of its future NGSO EESS satellites. This plan, which is suitable for EESS systems generally and

⁵ See, e.g., Space Frequency Coordination Group, X-Band Database (updated July 20, 2015), http://www.sfcgonline.org/Public%20Documents/SFCG_XBDB_20-July-2015.xlsx.

⁶ See Int’l Telecomm. Union, *System Design Guidelines for Earth Exploration-satellites Operating in the Band 8025-8400 MHz*, Rec. ITU-R SA. 1810 (approved June 22, 2007), available at <http://www.itu.int/rec/R-REC-SA.1810-0-200706-I>.

⁷ *Id.* at 3.

⁸ See 47 C.F.R. § 2.106.

can serve as a model for other operators, avoids the current density of operations in the X-band as well as restrictions by terrestrial services in the S-band.

A. 25.5-27 GHz Band (Space-to-Earth)

Under the Commission's Table of Frequency Allocations, the 25.5-27.0 GHz range in the Ka-band is allocated on a primary basis to EESS for federal and (pursuant to footnote US258) non-Federal users. For all global regions, there is a primary allocation for EESS in the *International Table*. Because Terra Bella's high-resolution imagery satellite system is an EESS pursuant to the Commission's rules (47 C.F.R. § 2.1), Terra Bella's intended operations are consistent with the U.S. Tables and *International Table*. Terra Bella is interested in employing wideband Ka-band transmitters in this band on future satellites for the downlink of satellite payload data. The characteristics of such transmitters would be compliant with the recommendations in ITU-R SA.1862.

B. 28.5-30 GHz Band (Earth-to-Space)

For Earth-to-space transmissions, the *International Table* allocates 28.5-30.0 GHz to EESS on a secondary basis in the United States and the rest of Region 2. The U.S. Tables do not provide a corresponding allocation specific to EESS, but they do allocate generally for Earth-to-space transmissions. Terra Bella is interested in a specific region of the band, 29.3-29.5 GHz, for the purpose of EESS Earth-to-space satellite command and control consistent with footnote 5.541. More particularly, Terra Bella contemplates narrowband links with typical bandwidths of 100 KHz to 1 MHz for the command and control of its satellites and to optimize mission data downlinks.

Given the secondary allocation for EESS Earth-to-space transmissions in the band, these applications require a frequency range that is not overly congested or contested by

other systems and services. The Ka-band meets this need and, as explained below, its use for this purpose is both technically feasible and compatible with other services.

Technical Feasibility. The Ka-band offers exceptional bandwidth for high downlink data rates for EESS missions, which are becoming increasingly necessary as new technologies enable more complex and higher resolution remote sensing instruments. The Ka-band, however, has greater susceptibility to rain and other link fade conditions. This can be overcome with adaptive downlink rate control schemes such as Adaptive Coding and Modulation (ACM) mechanisms. For optimal performance, though, these mechanisms require an uplink (Earth-to-space) control channel to inform the space transmitters of link conditions or otherwise control the downlink system. For a Ka-band Earth station dedicated to the mission data downlink, also utilizing the Ka-band for the channel control uplink offers system simplicity (single-band operation), weight savings, and cost efficiency for both the space and ground segments.

Satellite command and control uplinks are by nature narrowband, with typical bandwidth requirements between 100 KHz and 1 MHz. A band segment of just 200 MHz has the potential to support hundreds of these narrowband transmissions simultaneously if spaced appropriately in the band. For instance, in the case of downlink-only control channels where 100 KHz may be sufficient, as many as 1000 simultaneous uplink channels can be supported within 200 MHz of spectrum even with generous 100 KHz guard bands between those channels. With 1 MHz channels separated by 250 KHz guard bands, 160 simultaneous channels can be supported. In practice, even more simultaneous users can be supported in light of the rare conjunction of NGSO orbits and the use of high-gain directional ground antennas. Therefore, only a small portion of the Ka-band would be necessary to meet the foreseeable needs of the entire NGSO EESS community.

Compatibility with Other Services. Use of the Ka-band for EESS Earth-to-space transmissions is particularly compatible with other services in the band. Although any frequency in the currently allocated range of 28.5-30 GHz could be used, the range of 29.3-29.5 GHz is especially suitable. Recent filings and Commission actions related to Iridium,⁹ O3B,¹⁰ and Spectrum Frontiers,¹¹ as well as the OneWeb petition, involve hundreds of satellites and potentially thousands of ground terminals in parts of the band, particularly 27.5-29.3 GHz and 29.5-30 GHz. These plans create new challenges for NGSO EESS coordination and shared use of the Ka-band as an Earth-to-space satellite control channel. By contrast, the 29.3-29.5 GHz range continues to have a lower density of users and therefore greater potential for use by the NGSO EESS community on a non-interfering, shared basis with Fixed, Fixed-Satellite, and Mobile services.

III. Preservation of the 25.5-27 GHz and 29.3-29.5 GHz Bands

For the foregoing reasons, Terra Bella requests that the Commission give weight in its spectrum planning to future use of the 25.5-27 GHz and 29.3-29.5 GHz bands by non-Federal NGSO EESS systems. In particular, Terra Bella urges the Commission to consider the future use of these bands by NGSO EESS missions, along with compatible services that are present at densities low enough to facilitate simple coordination or simultaneous use. Even more specifically, Terra Bella urges the Commission to accommodate 25.5-27 GHz space-to-Earth EESS uses, where minimal active coordination is currently needed. In addition, Terra Bella urges the Commission to identify a selection of frequencies within the range of 28.5-30 GHz,

⁹ *In the Matter of Iridium Constellation LLC Application for Modification of Big LEO License to Change the Orbital Debris Mitigation Plan*, Order and Authorization, 29 FCC Rcd. 9422 (2014).

¹⁰ Letter from Jose P. Albuquerque, Chief, Satellite Division, International Bureau, FCC, to Suzanne Malloy, Vice President, Regulatory Affairs, O3b Limited, 31 FCC Rcd. 342 (Jan. 29, 2016), *available at* https://apps.fcc.gov/edocs_public/attachmatch/DA-16-99A1.pdf.

¹¹ *In the Matter of Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, et al.*, Report and Order and Further Notice of Proposed Rulemaking, GN Docket No. 14-177, *et al.* (July 14, 2016).

such as 29.3-29.5 GHz, that will be available for use by NGS0 EESS missions for satellite command and control purposes, on a shared basis with other compatible services.

Respectfully submitted,



Austin C. Schlick
Director of Communications Law, Google Inc.
Stephanie Selmer
Counsel, Google Inc.
Terra Bella Technologies Inc.
25 Massachusetts Avenue NW
Ninth Floor
Washington, DC 20001

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